

# UC San Diego

## Technical Reports

### Title

Drone Flight Manual UCSD Mangrove Imaging Procedure (Version 1.3)

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### Authors

Hsu, Astrid J  
Lo, Eric K  
Dorian, John B  
[et al.](#)

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# DRONE flight manual

UCSD Mangrove Imaging  
Procedure (Version 1.3)

## June 2021

This version of the manual covers flight preparation using DJI Phantom 4 Pro (P4P) and associated software and details for operations capturing Red-Green-Blue (RGB) imagery.

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For questions, contact Astrid Hsu at  
[ajhsu@ucsd.edu](mailto:ajhsu@ucsd.edu).

# Table of Contents

<b>Table of Contents</b>	1
<b>Acronyms</b>	2
<b>Overview</b>	3
<b>Trip Planning</b>	3
Crew Selection	3
Area of Interest (AOI)	4
Aircraft and Software Selection	4
Documentation Packet	4
Weather Conditions	5
<b>Pre-Trip Preparation</b>	5
Packing	5
Batteries	5
Digital Storage	6
Flight Planning	6
Flight Area	6
High-Altitude Flight	6
Low-Altitude Flight	7
Time Management	8
Flight Plan	8
Log Preparation	8
<b>Preflight</b>	8
Final Temporary Flight Restrictions Check	8
Weather Conditions	8
Takeoff/Landing Zone Safety	9
Visual Check	9
Line of Sight Verification	9
Hazard Recognition	9
Program Flight Software	9
Battery Check	10
Digital Storage Check	10
Drone Startup	10
Drone Health Check	10
Camera Configuration	10
Calibration Imaging	11
Begin Log Entry	12
<b>Takeoff</b>	12
Start and Control Checks	12
<b>During Flight</b>	12
Observation	12
Collision Hazards	12

Aircraft Monitoring .....	13
Battery Change .....	14
Data Management and Verification .....	14
<b>Landing</b> .....	15
<b>Postflight</b> .....	15
Imaging and Powering Down .....	15
Complete Log Entry .....	15
Data Download .....	15
<b>Data Submission</b> .....	16
Organization .....	16
Backup .....	16
Shipping Storage Media .....	16
<b>Appendix A--Programming Ground Station Pro</b> .....	17
Programs .....	17
Pre-Flight .....	17
Copy and Edit a Previous Mission .....	20
Checking Motion Blur .....	20
<b>Appendix B--Flight Log Form</b> .....	21
<b>Appendix C--Flight Checklist</b> .....	23

# Acronyms

<b>AOI</b>	Area of Interest
<b>DEM</b>	Digital Elevation Model
<b>GPS</b>	Global Positioning System
<b>GSP</b>	DJI Ground Station Pro
<b>P4P</b>	DJI Phantom 4 Pro
<b>RGB</b>	Red-Green-Blue
<b>RTH</b>	Return to Home
<b>SIO</b>	Scripps Institution of Oceanography
<b>UCSD</b>	University of California, San Diego

# Overview

The University of California, San Diego (UCSD) Engineers for Exploration and the Aburto Laboratory at the Scripps Institution of Oceanography (SIO) (henceforth UC San Diego team), along with Centro para la Biodiversidad Marina y Conservación, and the Gulf of California Marine Program, have collaborated to develop a pipeline for drone based aerial data acquisition and processing to produce high-quality image products. The resulting images are intended for use with machine learning to classify mangrove extent and species composition. This machine learning image processing procedure will be henceforth called the Image Processing Procedure. When completed, the Image Processing Procedure creates the following products:

- High-altitude wide area white-balanced visible-spectrum orthomosaic
- Low-altitude small area white-balanced visible-spectrum orthomosaic
- Digital elevation model (DEM)

This manual details field procedures for taking aerial red-green-blue (RGB) imagery of mangrove forests for the subsequent Image Processing Procedure. It includes instructions for safe drone operation, efficient time management, and functional data organization.

The UCSD team has also established procedures for acquiring similar data with the addition of multispectral imagery and GPS ground control points. Contact Professor Ryan Kastner at [kastner@ucsd.edu](mailto:kastner@ucsd.edu) for more information.

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## Trip Planning



### Crew Selection

Drone operation requires a minimum of two crew members, though three members improves efficiency. Below are the roles and their core responsibilities:

#### 1. Pilot

- Have appropriate regional certification and at least 10 hours of training
- Oversees the drone operation in accordance with applicable regulations
- Plans and programs flight plans into autopilot software
- Directs and coordinates the team's work

#### 2. Visual Observer

- Monitors the sky for potential hazards
- Maintains flight logs
- Assists the pilot in handling the flight hardware and calibration targets.

#### 3. Data Manager (optional)

- Ensures that the drone has sufficient data storage space
- Transfers and organizes data between flights
- Reviews data for quality assurance



## Area of Interest (AOI)

Select an AOI to fly based on level of interest and accessibility. Factors that may favor a site include interest in species composition, change in mangrove area over time, and survey of mangrove extent. Ensure that the AOI is sufficiently near to maintained roads or by boat, and that an adequately capable vehicle is available to complete the journey.

If reaching the AOI involves crossing international borders or requires commercial transportation such as by plane or train, carefully research any international cargo requirements or restrictions of the Department of Transportation, Federal Aviation Administration, or like organization of both the country of origin and county of destination. Drone batteries contain lithium, which is considered hazardous materials and generally restricted from air cargo transport.

Determine land ownership of the AOI so that the governing organization can be contacted to secure permission. Follow the requirements laid out by the land owner.



## Aircraft and Software Selection

The UCSD team has worked exclusively with the P4P. It was selected for its maintainability, battery life, gimbal, camera resolution, and price. The gimbal-mounted 20MP camera provides the resolution and stability necessary to produce high-quality images to create an orthomosaic and 3D model when these procedures are followed. Please note that, however, this drone is currently out of stock.

The UCSD team has used the DJI Ground Station Pro (GSP) software on an Apple iPad for programming flights. This program allows flight areas and parameters to be entered for auto-piloted flights with human supervision.



## Documentation Packet

Be sure to carry all pertinent flight and licensing information to the respective region. Also carry contact information for any relevant liaison, property owner, or authority. This list will be henceforth called *Drone Documentation Packet*.

- |   |   |
|---|---|
| <input type="checkbox"/> Pilot License      | <input type="checkbox"/> Written flight permissions   |
| <input type="checkbox"/> Drone registration | <input type="checkbox"/> Local liaison contact info   |
| <input type="checkbox"/> Flight plan        | <input type="checkbox"/> Local authority contact info |
| <input type="checkbox"/> Permits            | <input type="checkbox"/> Equipment sales receipts     |



## Weather Condition

Safe drone operation requires fairly temperate weather. Precipitation, heavy winds, and poor visibility make drone operation unsafe. Significantly overcast weather may also obscure sunlight and result in poor image quality. Be aware of weather seasonality and monitor weather forecasts prior to the flight date and reschedule if conditions are unfavorable.

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# Pre-Trip Preparation



## Packing

Here is a suggested checklist of items that should be taken to the field:

### Drone Essentials

- Drone
- Drone case
- Drone batteries
- Battery chargers
- Inverter and battery, or generator
- Drone controller
- Drone documentation packet
- iPad with flight software

### Calibration

- Calibration targets

### Drone Accessories

- Controller neck strap
- SD cards
- Spare propellers
- USB cables
- Landing pad

### Processing Equipment

- SD card reader
- Laptop computer
- Laptop charger

### Personnel Equipment

- Binoculars
- Camera for media/PR photos
- Physical maps of the AOI
- Pens/pencils
- Clipboards
- Camping chairs
- Water
- First aid supplies



## Batteries

Batteries can take up to an hour and a half to fully charge, so bring fully charged batteries into the field. If using the P4P, prepare at least three fully-charged batteries to image a single mangrove forest of about a quarter of a square kilometer. Prepare more batteries or a charging mechanism for the batteries if imaging more area. A small

electric generator or AC inverter connected to an extra car battery can provide power for charging drone batteries, controllers, and laptops.

Use documentation from the drone's manufacturer combined with your own experience to estimate the number and duration of flights, and how many batteries needed to fly.



## Digital Storage

Take at least two high-capacity SD cards (i.e. 32 GB) compatible with the drone to be used on the trip. This allows the drone to fly continuously, switching SD cards each flight. The crew can then work concurrently to transfer data to a laptop or other storage device, organize the images, and verify the quantity and quality of images is as expected.



## Flight Planning

The Image Processing procedure requires two sets of images flown at different altitudes: 120 meters, and approximately 15 meters, though exact altitudes may vary depending on local conditions. A flight plan enables communication among crew members and with authorities.

### Flight Area

First check that the AOI is not within classified air space. If it is, obtain approval from the relevant authorities. Identify a viable take-off location in which the pilot can maintain visual contact with the drone as well as maintain a radio link between the drone and the controller. The take-off location--also known as home--should be a relatively flat area with a buffer of at least two meters around the landing pad free from objects in which the landing pad can be staked down.

### High-Altitude Flight

Flying the drone at or near 120 meters provides a good balance between flight time and resolution and is the standard altitude for most flights. Check the flight ceiling in the AOI and lower the altitude as needed to comply.

To program the flight software, create a flight plan using a photomap if possible, and use the graphical interface to draw a flight perimeter. Adjust the perimeter so that the drone will fly directly over the entire mangrove forest and exclude any populated areas. Make use of available satellite imagery to identify and avoid any potential hazards such as mountains or power lines. Step-by-step instructions can be found in *Appendix A*.

Make note of the flight statistics estimated by the flight software. A typical flight may have roughly 150 to 200 photos, depending on the size of the mangrove forest, but a significantly higher or lower estimate



(such as 20 or 500) may indicate incorrect settings. The course angle can also be adjusted to minimize flight time and change where the flight will start and stop. Have the drone begin farthest from home and end closer to home.

Since image processing results in some loss of resolution, it helps to maintain a target resolution so that the final processed images have sufficient resolution to work with the machine learning algorithms. Flights should have 2-3 cm resolution as listed in Ground Station Pro, which refers to ground sample distance.

Flight time should fit comfortably within typical safe single-battery flight time for this airframe. Some flight software may automatically split large flights to allow for battery replacement, but monitor battery usage regardless.

### Low-Altitude Flight

Images from the low-altitude flight are used to spot check machine algorithm output by identifying physiological features in the mangroves. Low-altitude flights do not attempt to image the entire AOI. Instead, they image a small area that transects the mangroves from shore to water.

The target altitude is 10 meters above canopy height. Higher than this obscures some helpful physiological features, while lower than this becomes difficult to process and may be unsafe to fly. When programming the flight ahead of time, use 15 meters as a placeholder.

Canopy height can be determined either with the drone or a range-finder. To use a drone, take manual control of the vehicle, aim the camera gimbal horizontally, and enable the diagonal grid on the flight software. Slowly fly the drone upward, facing the tallest feature in the AOI. When this feature is centered in the field of view, the drone's altitude can be used to approximate the canopy height. Rotate the drone 360 degrees to check for any taller obstacles. Add 10 meters to this canopy height to get the altitude that should be entered into the flight software.

As in the previous flight, draw a flight perimeter into the flight software around the AOI selected for flight. This flight should be flown in hover and capture mode with 85% overlap ratio on both the front and sides. Examine the estimated flight statistics. Aim for 250 to 350 photos for this flight, and if significantly more, reduce the AOI. If the AOI cannot be reduced while completing a transect with at least two passes, the overlap can be lowered to 80%. Keep resolution below one centimeter.

Hover and capture operation proceeds more slowly and may use more battery life, despite covering a smaller area. Monitor the battery use during flight and plan multiple flights if needed.

### Time Management

Prepare to visit no more than two sites in the same day unless the sites are very close together. High sun position can cause objectionable reflections in the images, so it is best to plan flights before 11:00 am and after 1:00 pm.

### Flight Plan

For seeking approval and if approached by law enforcement, have a clearly documented flight plan as well as your associated permits. This can be a single-paged document describing and mapping the AOI, as well as the exact location, altitude, duration, and purpose of each flight.



### Log Preparation

Prior to departure, print out several pages of flight log sheets (Appendix B). In the field, one person should be responsible for filling in the log as flights occur. The rest of the crew should periodically check that it is complete. Incomplete flight logs do not comply with regulation and can make it difficult to properly process the images.

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## PreFlight



### Final Temporary Flight Restrictions Check

Check for any notice to airmen from the respective country's flight agency concerning temporary flight restrictions and that the region does not have any GPS interference either.



### Weather Conditions

Once on-site and immediately prior to take-off, perform a visual assessment of the weather. Check for signs of precipitation or electrical activity by identifying any dark clouds in the vicinity. If such clouds are visible in the distance, consider wind speed and direction. Be sure to have all equipment packed away before the clouds arrive. Any visible lightning or sound of thunder should cause an immediate abort for the day. Even if there is no rain, there must be adequate light for imaging and sufficiently clear skies to maintain visual contact with the drone. A useful chart for clouds can be accessed and printed here by Sky Guide: <https://bit.ly/2UtiRc2>

Winds above 10 meter per second can cause the drone to land improperly and may cause significant reduction in battery life as it flies against the wind. A good rule of thumb is that wind speed should not be greater than 75% of maximum drone speed to ensure that your aircraft can fly against the wind. Operating temperatures should

be within the range provided by the drone and iPad user manual. High temperatures can cause equipment to overheat and either malfunction or shut down entirely. Plan accordingly. In the case of the P4P, the maximum temperature is 40° C.

Lastly, due to reflections when the sun is high in the sky, it is best to fly before 11:00 am and after 1:00 pm local time.



## Takeoff/Landing Zone Safety

Visually check the area surrounding the landing pad for any obstacles or people. There should be at least two meters of clear, flat ground around the pad, and people should be at least three meters away.



## Visual Check

Visually inspect the drone. Carefully examine the propellers to ensure that they are free of cracks or chips. Tug the props gently upwards to make sure that they are secured and manually spin them to ensure that they are free of debris. Look over the entire drone for any damage or anomalies. Also ensure that the battery is fully inserted and properly latched.

The gimbal lock and camera cover should be removed. Make sure that the gimbal has positive control and is not moving uncontrollably-- restart the drone if it does. Do not fly unless you are certain that the drone, its propellers, battery, and gimbal are all in good condition.



## Line of Sight Verification

Perform a final visual check of the area to be flown and confirm that line of sight will be possible throughout the flight. Account for terrain features, buildings and weather conditions.



## Hazard Recognition

Potential flight hazards can come in many forms. Possibilities include low-flying planes and helicopters, power lines, birds, and tall features such as trees. Identify anything that could come close to the drone during flight.



## Program Flight Software

If the flight plan hasn't already been programmed, enter it into GSP. If it has been programmed, review the area and flight characteristics. Check that the planned flight area matches expectations in terms of interesting features to be imaged and hazards to avoid. Follow the guidelines in the Flight Planning section.



## Battery Check

Always check that the drone battery is physically secured and enough charge prior to takeoff. Use this together with the percentage reported in the flight software to ensure that there is enough battery power to complete the flight.

Plan on landing with at least 30% charge to handle unexpected battery use that may arise from unexpected events. The further the distance that the drone has to return to home (RTH), the more charge should be kept in reserve. Be aware that the lithium-based batteries in drones may drain much faster as they approach empty. Make note of battery usage with each flight to help plan future flights more efficiently.



## Digital Storage Check

Swap the SD card between flights, and the card not currently being flown should have its data transferred to another device. If this is not possible, check the available storage on the SD card using the flight software or a laptop before each flight to ensure that there is enough space to capture all the images from flight.

The amount of space required will depend on the length of the flight. The flight software will provide an expected number of photos to be captured. 100 image files will occupy approximately 1.1 GB of space. A 3 GB SD card will hold all but the longest flights.



## Drone Startup

Once the above checks are complete, power up the flight controller and the drone. Connect the iPad to the controller. Check that the flight software is properly connected to the device. See the manufacturer's documentation for troubleshooting.



## Drone Health Check

On the iPad screen, check that the drone is connecting with at least 6 GPS satellites. This is the threshold to ensure that we are collecting enough GPS data to construct a 3D model. Ensure that the home position is set to a reasonable location. If using the automatic RTH feature, ensure that the RTH altitude is high enough to avoid obstacles. Address any and all warnings that may come up, such as a lack of radiolink or obstructed sensor. Refer to the respective user manual as needed. Lastly, check that the battery of the iPad and controller are above 30%, and that the drone battery is above 90%.

To troubleshoot any problems, refer to the respective user manual.



## Camera Configuration

Once the drone is powered up, setup the camera to have JPEG file format with the highest available resolution. Set white balance to sunny. The exposure settings will take some consideration prior to each flight.

Use Aperture Priority mode (A) and set aperture to f/6.3 and ISO to 100. Before flight, fill the camera frame with either a grey card or vegetation, and observe the shutter speed. Using the altitude and planned velocity of the mission, look up the minimum shutter speed to avoid motion blur. Increase the ISO until the shutter speed is faster than the value specified in the table, or ISO reaches 800. If ISO 800 is required, lighting may be inadequate for imaging, and flight should be reconsidered. In case of partially cloudy or otherwise changing lighting conditions, the ISO should be set more conservatively to avoid motion blur when the sun is occluded. In case of high wind, the vegetation and nonrigid elements may move enough to cause motion blur as well. The shutter speed value should be checked periodically in flight to ensure it does not drop below the minimum shutter speed as indicated in the table below to avoid motion blur.

Altitude (m)	1 m/s	2 m/s	4 m/s	6 m/s	8 m/s	10 m/s	12 m/s	14 m/s	16 m/s
10	1/400	1/800	1/1600	1/2500	1/3200	1/4000	--	--	--
20	1/200	1/400	1/800	1/1250	1/1600	1/2000	1/2500	1/3200	1/3200
40	1/100	1/200	1/400	1/800	1/800	1/1000	1/1250	1/1600	1/1600
80	1/60	1/125	1/250	1/400	1/500	1/640	1/800	1/1000	1/1000
100	1/40	1/80	1/160	1/250	1/320	1/400	1/500	1/640	1/640
120	1/30	1/60	1/125	1/200	1/250	1/320	1/400	1/500	1/500

Finally, check that the gimbal is still stabilizing correctly and is faced straight down.



## Calibration Imaging

As part of image processing, color correction will be performed to improve the color consistency of the final image product. This requires photos of a calibration card prior to each flight.

Make sure the gray calibration card is positioned on a neutral-toned surface, ideally a medium gray. Set the exposure to automatic and be sure the card is level and shadow-free. Have one person hold the drone above the gray card so that the gray portion fills as much of the camera field of view as possible. Take three pictures of the card. Repeat this before and after every flight.



## Begin Log Entry

Prior to takeoff, begin filling in a line on the flight log. Be sure to make note of which battery is in use and the time the drone is taking off.

All of these checks are available in a pre-flight checklist in *Appendix C*.

---

# Takeoff



## Start and Control Checks

Once the preflight procedures are complete, start the propellers. Be prepared to quickly shut down the propellers at the moment of takeoff should the unexpected occur.

For the first flight, and any flight that follows a hard landing or other mishap, takeoff under manual control. Slowly raise the drone several feet off the ground let it hover for around 15 seconds. Make sure that it can maintain its position. If it cannot, this may indicate a problem with its sensors or flight control software. If the hover test is successful, gently move each joystick in all four directions and check that the drone responds accordingly.

If the previous tests are successful, the drone is ready to fly and the autopilot can be instructed to begin the flight plan.

---

# During Flight



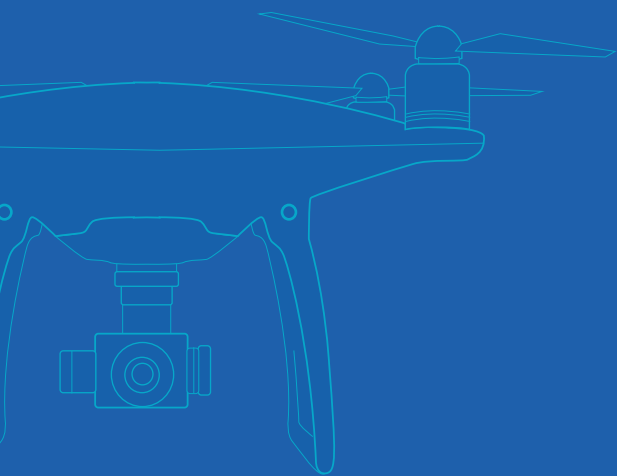
## Observation

While the drone is in the air, both the pilot and visual observer should maintain visual contact with the drone. Binoculars may help if the drone is flying further away. Both pilot and visual observer should monitor weather conditions and abort the flight if conditions become unfavorable.

### Collision Hazards

It is critical that crew members watch the sky for hazards. Mobile hazards such as birds or low-flying aircraft may appear at any time and with short notice. While all crew members should watch both the drone and for hazards, the flight operator will prioritize visual contact with the drone and the visual observer will prioritize monitoring for hazards.

If hazards are identified in the vicinity of the drone, the flight operator should take manual control of the drone. Birds may pose a significant challenge as their flight can be unpredictable and they may choose to follow or attack the drone. The appearance of hazards may require a flight abort and RTH until the hazards move away. Once the hazards pass, the autopilot can be reactivated to continue the flight. Take note of the battery power used for avoiding obstacles.



## Aircraft Monitoring

Monitor the stability of your aircraft using the bubble level in the lower left hand corner and that it does not exceed 45°. Note that the stability of the aircraft is largely influenced by the wind, and a strong tilt of the aircraft will not produce good imagery. The pilot should also monitor the live video feed of the drone in case gimbal control destabilizes. If either drone or gimbal become unstable, land the drone. In the case of high winds, fly when conditions are more favorable. In the case of gimbal control failure, restart the drone. If the problem persists, refer to the user manual.

Monitoring battery usage is key. Track how much battery is used for the drone to get to the start of its flight pattern, and to complete the first transect. This information will help you anticipate how many more transects can be flown while still leaving enough power for the return flight and a 30% reserve for unanticipated maneuvering.

Also ensure that the drone is consistently connected to at least six GPS satellites and that it has a radio link with the controller at all times. If the drone is not connected with enough GPS satellites or the radio link begins to falter, abort the flight and manually RTH. Without a good GPS signal, the drone will have trouble returning home automatically and lack of GPS will also compound the issue of a lost radio link. The flight can be attempted later when more satellites come in range. If the radiolink cannot be maintained, some or all of the flight may need to be flown from a closer operating area.

What each flight member must monitor during flight can be distilled into the following:

### Pilot

- Stability of drone
- Exposure of images (shutter speed above minimum)
- Hazards

### Visual Observer

- Flight hazards
- Flight logs
- Image calibration

### Data Manager

- Image quality
- Back-ups of SD cards
- Sufficient space on SD cards





## Battery Change

If there is not enough battery power to comfortably complete a flight, the battery will have to be replaced. After the drone has completed the current transect, take manual control of the drone to fly back and land. Power down the drone and replace the battery with one that is fully-charged. Power up the drone and manually fly back to where it was interrupted. In GSP, tap “Resume Mission” to continue the flight.



## Data Management and Verification

If a third person is available, they can manage the data captured so far. The SD card should be switched between flights, making the data from the last flight available for review. Image files will likely be contained all together in a single folder, often within a folder labeled “DCIM”. DJI files are automatically numbered from 001 to 999 and will begin to populate a new folder when the number resets.

An initial check will quickly reveal if the flight failed to produce any images. Also check that there are a reasonable number of image files in case the drone stopped taking images part way through the flight. If this happens the crew should work together to troubleshoot the cause and repeat the flight.

Once the images are found, use a laptop or other storage device, and prepare a unique folder for the flight. The following folder and naming scheme is recommended. Folders are separated by a ‘>’ character.

**country\_region > location\_date > site > flight**

This scheme flows from the most general to the most specific information starting with the country and region. Region may be a state or province. Location indicates a specific city or area and can be abbreviated with three letters. Date is written in “YYYY-MM-DD” format. The site indicates the order in which a specific flight area was visited during the trip. The flight indicates the order in which a flight occurred at a specific site. The following is an example of folder names for a flight performed in Puerto San Carlos, Mexico:

**mexico\_baja\_california\_sur > psc\_2018-07-10 > site01 > flight03**

Once these folders exist and are properly named, identify and copy the images from the SD card. If it is unclear which images belong to which flight, refer to the times on the flight log to select the correct images. Note that the time on the drone may be inaccurate, especially when travelling across time zones, and may change in an attempt at self-correction.

Review the copied images and verify that the images match the expected flight. Reorganize as needed. Then scrutinize the image quality for detail in light and dark regions, blur, or excessive sun reflections. Poor quality images demands reflying as time and batteries permit.



Perform a final check of the images and that they have been copied without errors. Once verified, they can be erased from the SD card.

---

## Landing



### Landing

If imaging your AOI in a lawnmower pattern, on bringing the drone back in, fly diagonally across your AOI and capture images. We found that this pattern has helped minimize distortions for image processing.

If landing automatically, watch for errant behavior during the drone's descent, such as attempting to land at the wrong location or descending at an angle. It is also possible for a malfunction to cause the drone to plummet to the ground at high velocity. Be ready to take over manually and correct any of these behaviors.

For a manual landing, move the drone slowly and carefully to land on the target. As the drone gets very close to the ground, the air moved by the propellers reflects back up and causes instability so avoid fine adjustments directly above the landing pad.

---

## Postflight



### Imaging and Powering Down

Once the drone has come to rest on the landing pad, stop the propellers. Take an additional set of calibration images--See the previous Calibration Images section for instructions.

The flight is now complete and the drone can be powered down.



### Complete Log Entry

Complete all flight information on the flight log. Note any unusual occurrences during flight such as flight incidents, unexpected changes in weather that could impact image quality, and anomalous drone behavior.



### Data Download

If a third crew member has not already been copying and organizing images, now is a good time to do so. Remove the SD card and connect it to a laptop. See the above section on Data Management and Verification for instructions.

# Data Submission



## Organization

After returning from the field take the opportunity to check the file organization one more time. Be sure that files are all clearly organized using the methods described in the Data Management and Verification section above. Check once more for adequate image quality and make notes of any missing data.



## Backup

Copy the trip's data to your own storage device. If possible make a second copy on a separate device to protect against drive failure. Note the storage space required to hold all the data.



## Shipping Storage Media

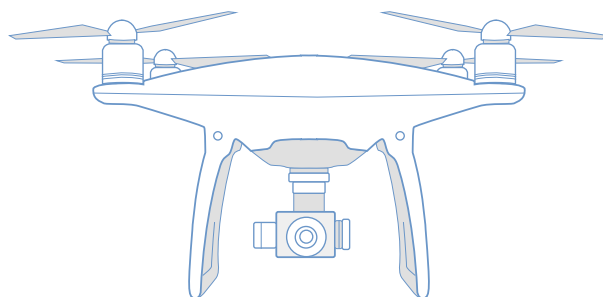
Procure a storage device such as an external hard drive or large SD card that can hold all the data from the trip. Copy all the data, including properly named folders, to the storage device. Verify that the transfer succeeded by opening some of the files.

Carefully package the storage device with adequate dunnage or padded envelope for protection. Select a shipping method with a tracking number. Storage devices should be shipped to:

### **The Aburto Lab**

Scripps Institution of Oceanography  
UC San Diego  
9500 Gilman Drive #0202  
La Jolla CA, 92093-0202

Once shipped, contact Astrid Hsu in the UCSD Aburto Lab at [ajhsu@ucsd.edu](mailto:ajhsu@ucsd.edu) to provide the tracking information and estimated time of arrival. Check that the package was delivered after the estimated delivery date.



# Appendix A

## Programming Ground Station Pro

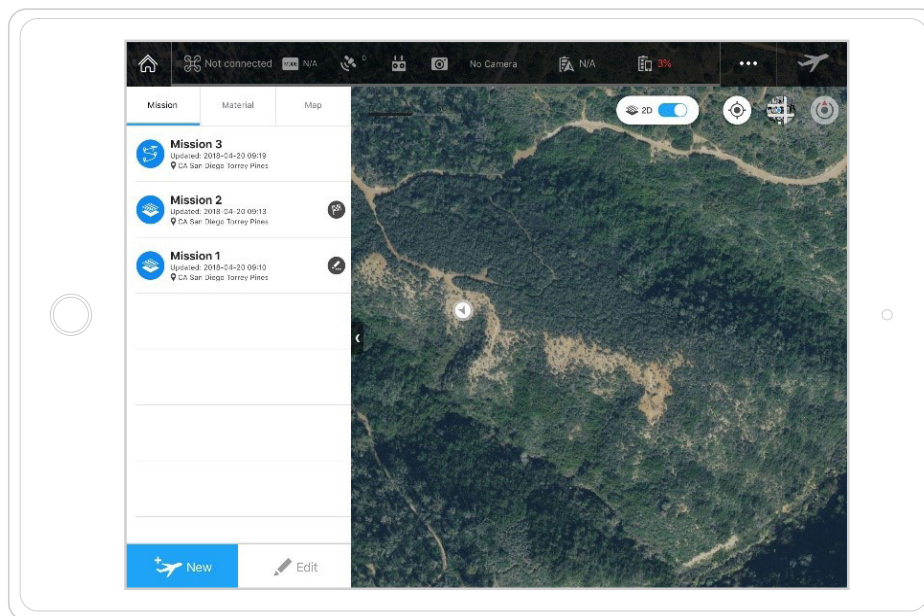
Follow these instructions to program a flight plan into the DJI Ground Station Pro (GSP) flight software that will provide the drone with the necessary information to capture all the desired images on autopilot.

### Programs

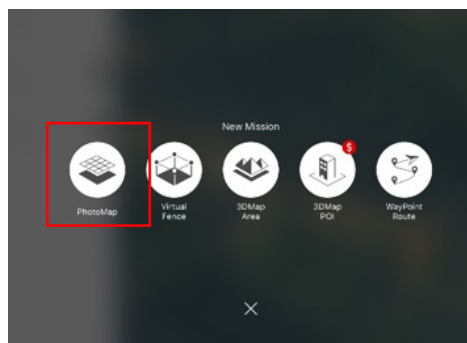
- DJI Go/DJI Go 4.0, dependent on your drone
- DJI Ground Station Pro

### Pre-Flight

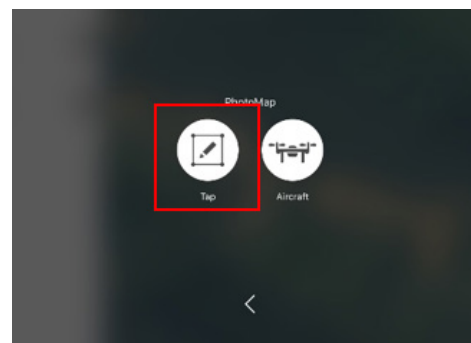
1. Define area of interest (AOI) with mangrove team and identify take-off points.
2. In DJI GS Pro, create a new mission on the lower left-hand corner.



3. Choose PhotoMap.

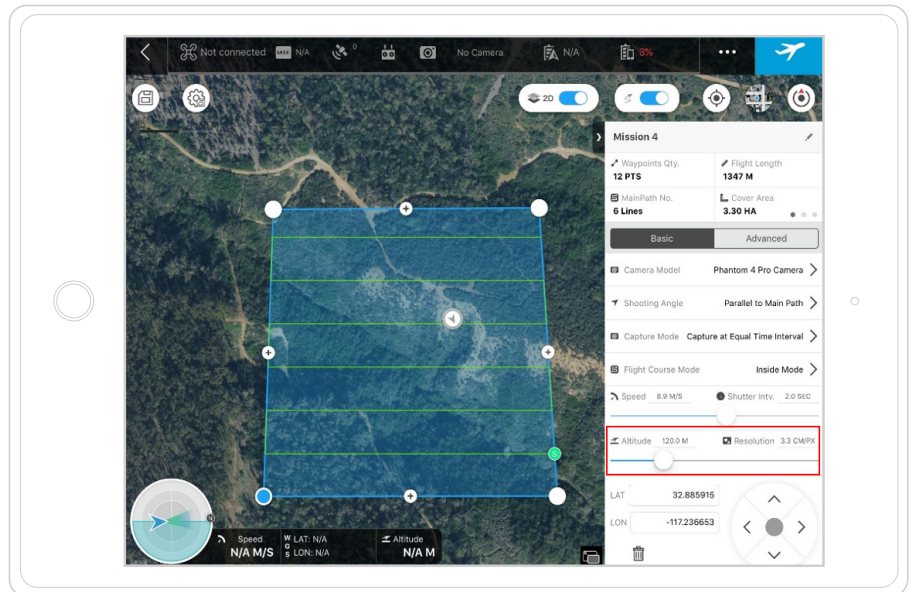


4. Select Tap.

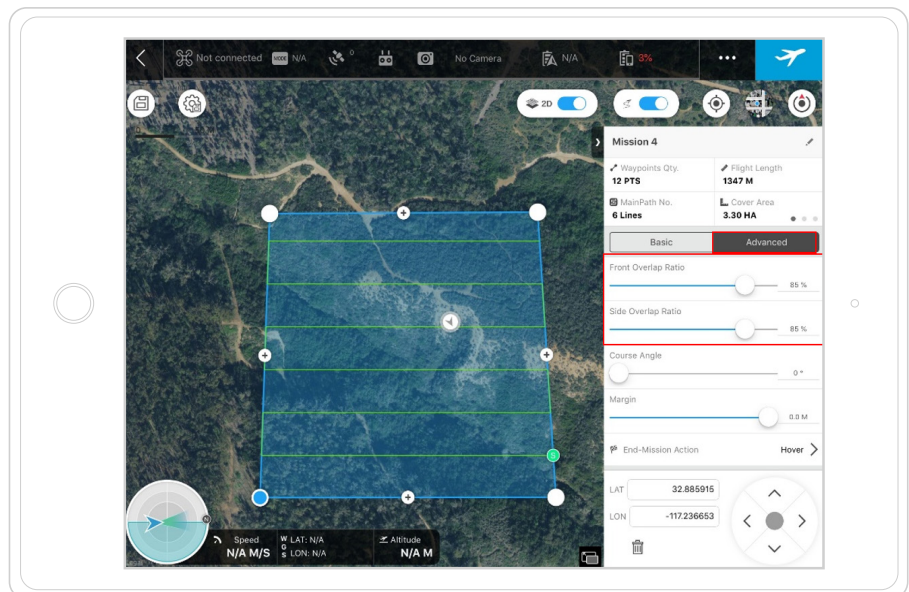


5. Create your polygon of AOI.
6. If your site's imagery is cloud covered, upload a cloud-free kmz image file to the software. Alternatively, if you are already in the field, select "Aircraft" instead of "Tap". This feature will enable the pilot to fly the drone along the perimeter of their AOI to create their polygon.

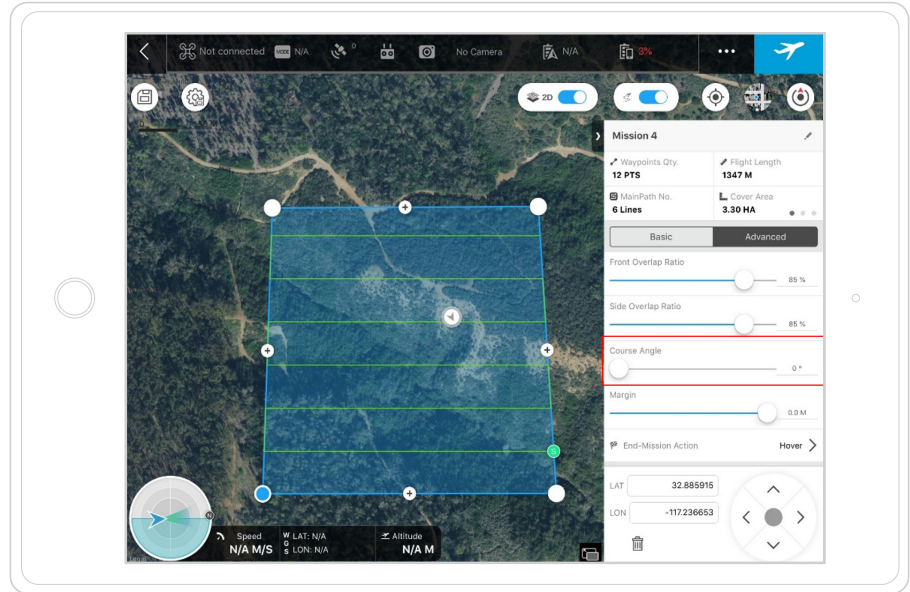
7. On the right side of the screen is a navigation bar. Under basic, define a tentative altitude. This will be 120 or 15 meters for the high and low altitude flights respectively. These must be revisited prior to flight to ensure safe operation.



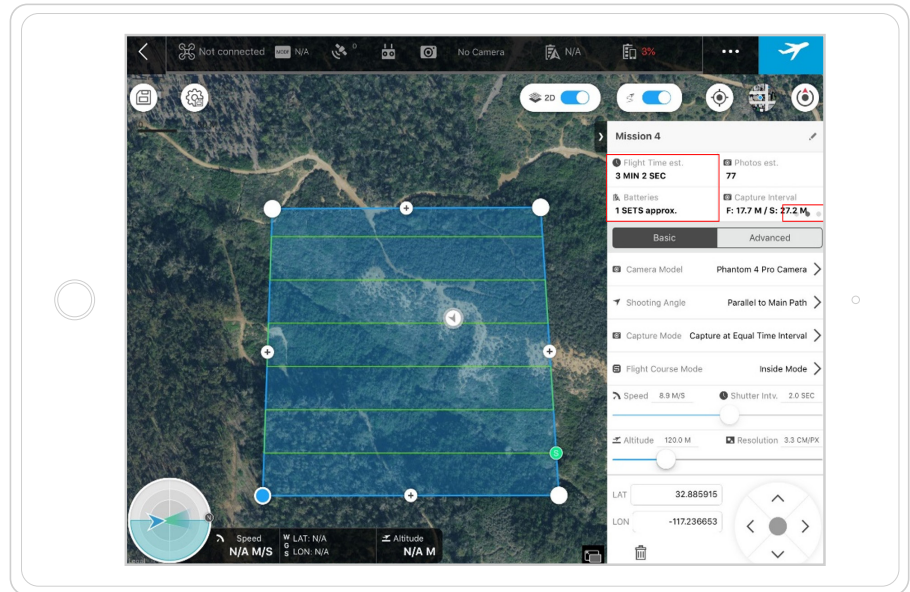
8. Navigate to Advanced, and select the overlap on both front and side overlap. This is 80% for high-altitude flights and 85% for low-altitude flights.



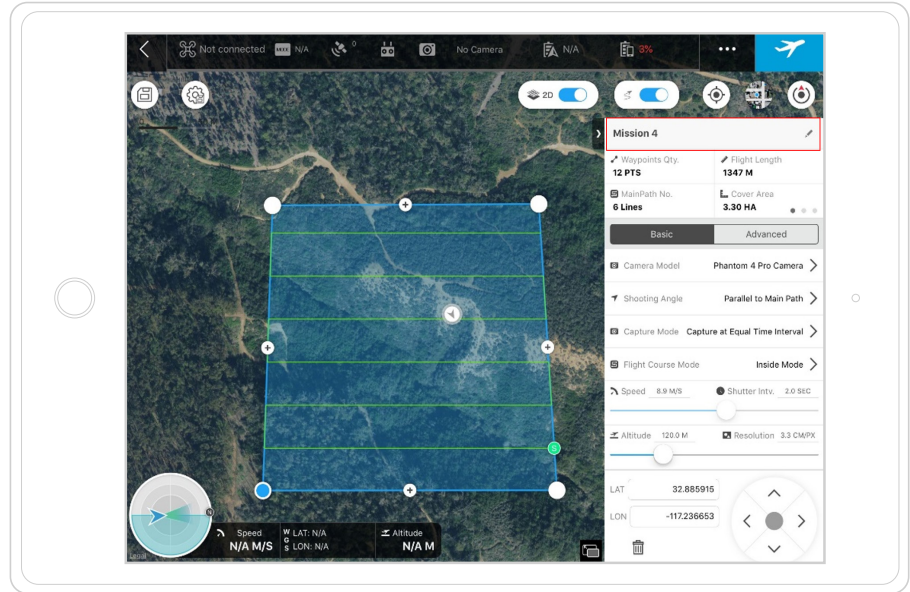
9. Adjust the course angle to reduce the flight time and to fly to the farthest point first.



10. Navigate back to Basic, and swipe left on the upper section of the navigation bar to see flight time and approximate number of batteries needed.



11. Rename Mission as Site [number]-120m.

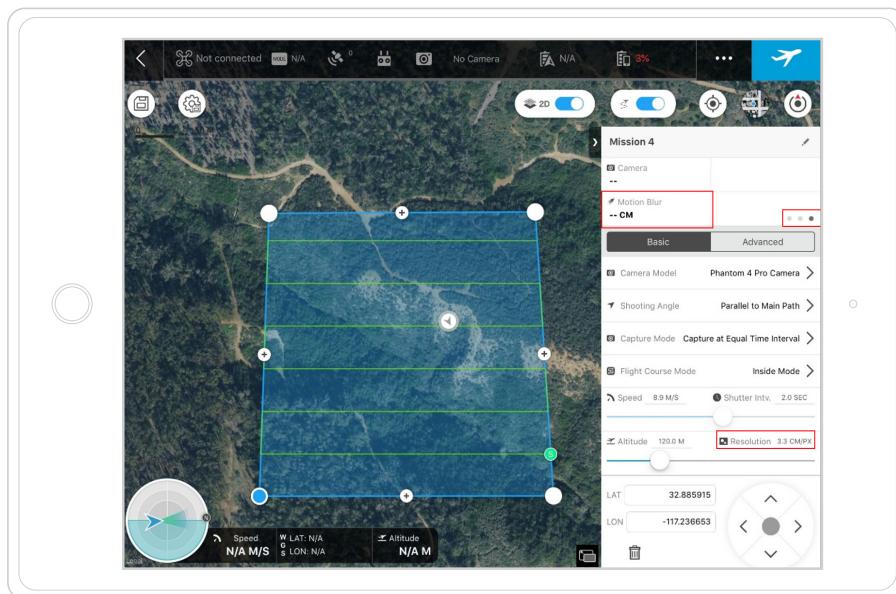


## Copy and Edit a Previous Mission

Swipe left on the 120 mission, and select copy. You can rename and change the parameters as relevant.

## Checking Motion Blur

12. To maintain high resolution image, swipe left on the upper section of the navigation bar until you see Motion Blur. While holding the drone at least a meter off the ground (with the camera pointed straight down), check to make sure that Motion Blur is less than the resolution.



# Appendix B

## Flight Log Form

Use the following flight log form to record flight information in the field. Be sure to print out extra copies.





# Appendix C

## Flight Checklist

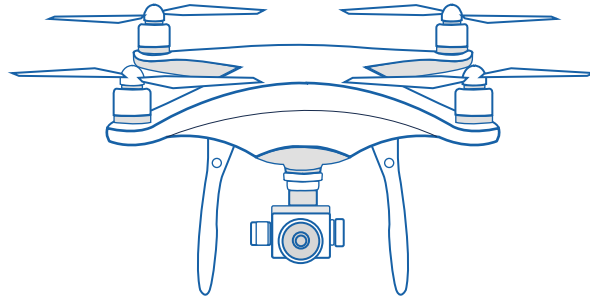
Print the following flight checklist as a quick field reference to remember all the checks and tasks needed for a successful flight.

Pre-Flight	In Flight	Post-Flight
<input type="checkbox"/> Check weather <input type="checkbox"/> Check visibility <input type="checkbox"/> Check for TFRs <input type="checkbox"/> Program a. pilot <input type="checkbox"/> Area <input type="checkbox"/> Altitude <input type="checkbox"/> Overlap <input type="checkbox"/> Begin log entry <input type="checkbox"/> Check SD space <input type="checkbox"/> Check battery <input type="checkbox"/> Check propellers <input type="checkbox"/> Remove gim. lock <input type="checkbox"/> Turn on controller <input type="checkbox"/> Turn on aircraft <input type="checkbox"/> Check sensor power <input type="checkbox"/> Set camera exposure <input type="checkbox"/> Start recording sensors <input type="checkbox"/> Take calibration images	<input type="checkbox"/> Start propellers <input type="checkbox"/> Hover 15 sec. <input type="checkbox"/> Test controls <input type="checkbox"/> Engage a. Pilot <input type="checkbox"/> Watch for: <input type="checkbox"/> Obstacles <input type="checkbox"/> Planes <input type="checkbox"/> Birds <input type="checkbox"/> Cover calibration targets <input type="checkbox"/> Organize files from last flight <input type="checkbox"/> Verify data quality from last flight	<input type="checkbox"/> Stop propellers <input type="checkbox"/> Stop sensors <input type="checkbox"/> Turn off aircraft <input type="checkbox"/> Turn off controller <input type="checkbox"/> Complete log entry <input type="checkbox"/> Remove SD card <input type="checkbox"/> Download sensor data

Pre-Flight	In Flight	Post-Flight
<input type="checkbox"/> Check weather <input type="checkbox"/> Check visibility <input type="checkbox"/> Check for TFRs <input type="checkbox"/> Program a. pilot <input type="checkbox"/> Area <input type="checkbox"/> Altitude <input type="checkbox"/> Overlap <input type="checkbox"/> Begin log entry <input type="checkbox"/> Check SD space <input type="checkbox"/> Check battery <input type="checkbox"/> Check propellers <input type="checkbox"/> Remove gim. lock <input type="checkbox"/> Turn on controller <input type="checkbox"/> Turn on aircraft <input type="checkbox"/> Check sensor power <input type="checkbox"/> Set camera exposure <input type="checkbox"/> Start recording sensors <input type="checkbox"/> Take calibration images	<input type="checkbox"/> Start propellers <input type="checkbox"/> Hover 15 sec. <input type="checkbox"/> Test controls <input type="checkbox"/> Engage a. Pilot <input type="checkbox"/> Watch for: <input type="checkbox"/> Obstacles <input type="checkbox"/> Planes <input type="checkbox"/> Birds <input type="checkbox"/> Cover calibration targets <input type="checkbox"/> Organize files from last flight <input type="checkbox"/> Verify data quality from last flight	<input type="checkbox"/> Stop propellers <input type="checkbox"/> Stop sensors <input type="checkbox"/> Turn off aircraft <input type="checkbox"/> Turn off controller <input type="checkbox"/> Complete log entry <input type="checkbox"/> Remove SD card <input type="checkbox"/> Download sensor data

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# Drone Flight Manual

UCSD Mangrove Imaging Procedure (Version 1.2)

July 2019

